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Phantom Limb, Phantom Pain and Stump Pain (Part II)

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ABSTRACT: Sensations of pain in that projection of the Body Image which is phantom limbs constitute are abnormal atate. Types I and II phantom limbs are useful as feedback mechanisms when unaccompanied by pain; when pain exists, it is felt to indicate the patient's unresolved desire for his lost limbs. It is necessary to make a careful analysis of the factors behind phantom-limb pain (livelihood, anxieties, social circumstances, suitability of prosthesis, etc.) and to devise appropriate means of resolving them. Phantom limb, phantom pain and stump pain are mutually related to their appearance, and the phantom pain has some psychosomatic factors. Phantom pain provides a method of interpersonal communication of medical staffs, and it is important to detect, analize, and discuss factors behind the pain in order to treat it properly. There are several treatment approaches known such as psychotherapy, hipnotherapy, antidepressant drugs and so on.

II. The Natural Disappearance of Phantom Limbs

Phantom limbs tent to fade away in most amputees after a certain period of time. A sample of 115 amputees was examined for the time lengths involved in this process. Included in the sample were 40 upper extremity amputees and 75 lower extremity amputees. Of the upper extremity amputees, 77.5% showed phantom limb disappearance after 3 years, and 95% after 5 years. Among the lower extremity amputees, the figures were 65% after 3 years and 86% after 5 years. In comparison, a separate study of 6 multiple extremity amputees showed that 83% experienced phantom limb disappearance after 3 years.

In cases where consciousness of phantom limbs remains after a period of 5 years, consciousness of phantom limbs remains after a period of 5 years, continued existence of the limb is a strong possibility if left untreated.

III. Pain in Amputees

Under conditions of normal health the human organism does not suffer from feelings of constant pain. Thus sensations of pain in that projection of the body image which is a phantom limb constitute an abnormal condittion.

The disapperance of a phantom limb implies the simultaneous disappearance of phantom-limb pain. Psychotherapy is quite effective in this regard, though the reappearance of both limb and pain cannot be ruled out since phan-

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tom limb disapperance is a reversible process. It is therefore nesessary to make a careful analysis of the factors behind phantom-limb pain (livelihood anxieties, social circumstances, suitability of prosthesis, etc.) and to devise appropriate means of resolving them.

Not all phantom limbs are accompanied by phantom-limb pain. Pediatric amputees, for example, do not experience the phenomenon of phantom limbs and are consequently free of any associated pain. Such pain only starts to appear about the age of 15, due, it is believed, to the strengthening of the body image which occurs at this time.

Phantom-limb pain is closely related to the degree of consciousness of the phantom limb : when this consciousness is strong a corresponding sense of phantom-limb pain is more likely to exist. Generally speaking, phantom-limb consciousness tends to be clearest in those areas which, in the normal anatomy, receive the greatest amount of use and stimulation. Hence phantom limb images of hands, fingers, and thumbs in the upper extremities and of feet, heels, and toes in the lower extremities are quite common. There is a recognised relationship between phantom limbs, phantom-limb pain, and stump pain ; when the former two disappear the latter tends to fade away as well.

1. Pain

Pain is defined by the International Pain Academy as an unpleasant sensory and emotional experience associated with, or described in terms of, actual or potential tissue damage. The word "pain" generally indicates the conscious perception of a signal transmitted from the body's pain receptors via the peripheral and central nervous systems. Such perceptions interact with the body of past experiences stored in the memory to produce such typical reactions to pain as fear, perspiration, elevated blood pressure, altered facial expression, and increased urination. The subjective element of pain is thus quite large.

a. The transmission of pain

Naked nerve endings comprise the sense receptors for pain ; pain impulses from these receptors are transmitted to the central nervous system via two fiber systems, one composed of myelinated A σ fibers and the other of unmyelinated C fibers. Both fiber groups end in the spinal cord, where they synapse on neurons in the dorsal horn. Axons from these neurons cross the midline and ascend to the ventral posteromedial and posterolateral nuclei of the thalamus. There they synapse again and travel to the postcentral gyri. The brain's "pain center" is said to lie in this area of the brain, though recent theories postulate that the entire brain is involved in the perception of pain.

The types of stimuli which can cause pain are many ; pain can be induced mechanically, physically, and electrically, as well as chemically through the use of acids, bases, histamines, serotonin, and other substances.

B. Clinical classifications of pain

1) Peripheral pain : a) superficial pain (from receptors located in the skin and mucous membranes, b) deep pain (visceral, joint, pleural, and peritoneal pain), c) referred pain (pain sensed in areas separate from the point of stimulus).

2) Central pain : a) pain resulting from stimuli to the spinal cord, brainstem, thalamus, or cortex ; includes referred pain.

3) Psychogenic pain : pain caused by emotional rather than organic factors, including, a) primitive reactions related to the sur-

vival instinct, b) suffering due to the loss of a beloved person or object, c) long term psychogenic pain rooted in personal relationship problems.

c. The nature of pain

1) Visceral pain differs in character from superficial pain due to its transmission by the slow C fibers rather than by the faster A σ fibers.

2) The strength of a pain sensation is not always proportionate to the body's reaction to it.

3) When 2 or more pain sensations are experienced at the same time, awareness generally occurs of the stronger one only.

4) Adaptation to pain stimuli rarel occurs. Sensitivity often increases with continued exposure to pain.

5) Physical debility, anxiety, and lack of sleep increase the body's sensitivity to pain.

Generally speaking, two stimuli of differing nature act upon the body in contradictory ways, causing both synergistic and exclusionary reactions. This is the case with sensations of heat and pain.

The suffering experienced by a patient in pain takes two forms : 1) the discomfort caused by the pain itself, 2) the anxiety arising as a result of the pain. Long term continuation of pain can lead to dipressive states ; psychotherapy is hence a beneficial part of pain treatment.

The emotional and psychological manifestations of pain vary from person to person. They are influenced by the individual's anxiety level and past experiences, and alter with the passage of time. Race, culture, religion, and customs also have their effect on the subjective elements of pain, as do sex and age : generally speaking, women and the elderly have a lower threshold and tolerance for pain. As there is an element of conditioned reflex in people's reaction to pain, it si even possible to change it from an unpleasant to a pleasant sensation. Mental associations can also change pain from a physical to an emotional experience.

d. Psychiatric pain

Pain is classified psychiatrically as 1) that arising from bodily factors or from the desperation accompanying intense physical discomfort (treatable with anti-depressant drugs), and 2) that caused by psychological factors, pariticularly hysteria (arising from mental conflict and frustration, and not amenablr to anti-depressant drugs ; psychotherapy required). Phantom-limb pain displays elements of both of the above types. It shows response both to drugs therapy with Imipramine (Tofranil), as reported by Sawamura, and to psychotherapy, as reported by Otsuka.

In addition to serving as a warning of physical illness and psychological distress, pain also provides a method of interpersonal communication. The pain reported by those suffering from neurosis and hysteria, for example, is employed by them in an attempt to gain sympathy and attention. People of low intellectural or social standing also complain of pain at times in an attempt ot open the paths of communication, as pain can be a effective means of conveying one's situation to others.

Psychogenic pain, as defined above, is a form of psychiatric pain.

e. A σ fibers and C fibers

The myelinated fibers of the A σ fiber pain transmission system are small, about 1-5 μm in diameter (av. 3 μm), and conduct pain impulses to the central nervous system at a rate of about 15-40 m/s. The pain sensations received through this fiber group are sharp, keen, and

localized ; they reach the central nervous system immediately following the pain stimulus and generally disappear soon after its cessation.

The unmyelinated fibers of the C fiber pain transmission system are 0.3 to 1.5 μm in diameter, and convey impulses at a speed of approximately 0.6-2.0 m/s. They form withdrawal reflexes easily. Stimulation of this fiber group leads to a dull, diffuse pain sensation which continues after the cessation of the pain stimulus. Pain resulting from such conditions as subcutaneous inflammation is transmitted to the central nervous system via C fibers, as is transmitted to the central nervous system via C fibers, as is the joint and muscle pain "sensed" by phantom limbs.

The proportion of A σ fibers to C fibers is 1 : 4 in the dorsal root and 1 : 8-9 in visceral nerves. A σ fibers, with a threshold 1/5 that of C fibers, respond to far lower levels of stimulation.

When a pain stimulus is located in peripheral areas, the fast pain conveyed by A σ fibers is relatively easy to differentiate from the slow pain of C fibers, but as the stimulus moves closer to the central region of the body such differentiation becomes increasingly difficult.

C fibers are less susceptible to pressure and hypoxia than A σ fibers, and thus retain unpleasant feelings of pain much longer. C fibers, however, are susceptible to selective numbing through the use of anesthetics and such substances as alcohol, and their function is altered under a variety of conditions. Psychological excitement, for example, can greatly reduce the body's perception of pain.

Pain receptors and nerve fibers are relatively unspecialized, and are capable of sensing also heat, pressure, and contact. It is only when stimuli pass a certain threshold that they are perceived as "pain"; these same stimuli, when applied at appropriate levels in the form of thermotherapy, massage, and kinesitherapy, can serve an analgesic function.

f. Tissue damage and nerve regeneration

In the regeneration process of damaged tissue, a proliferation of new blood vessels and connective tissue first occurs, leading to granulation and eventual scarification of the wound. Following this, the number of blood vessels reduces until it returns to normal.

Nerve tissue regeneration follows much the same pattern as that of blood vessels : initial proliferation of unmyelinated nerve fibers is followed, subsequent to tissue regeneration, by the degeneration and disappearance of most these fibers. The mature fibers which remain are covered with myelin. Nerve fiber regeneration is, of course, influenced by the various conditions associated with the original injury : the type and extent of damage, the presence of pathogens and their classification, the individual reaction of the body to the injury, etc.

The regeneration pattern of the nerves can affect the final sensitivity of the healed wound. When, for example, there is a continuation of the growth of the original unmyelinated fibers and a delay in their later degeneration, a condition of localized hypersensitivity results. This is due to the fact that the newly grown unmyelinated fibers tend to spread impulses in a diffuse pattern to other fibers in the area, resulting in what functions like an extra synapse. Thus, when a motor impulse is conveyed to the area of the regenerated tissue, numerous sensory nerves are stimulated and a sharp pain impulse is conveyed to the central nervous system. A long term local increase in the number of unmyelinated nerve fibers is found in cases of causalgia associated with severed sen-

sory nerve fibers, a possible explanation for the acute pain of this condition.

g. Pain suppression mechanisms

1) The gate control theory (Melzack, Wall ; 1965). This theory proposes that stimulation of the A σ fibers, with their lower threshold, can block pain transmission in the C fibers.

2) Endogenous pain control mechanism (Reynolds, 1969). This mechanism is based on the presence of endogenously produced morphine-like substances in the body, known as endorphins and enkephalins. These substances, believed to be fragments of the pituitary hormone B-Lipotropin, bind with the opiate receptor sites that function in pain perception and thus produce analgesia in the A σ and C fibers. The same pain stimulus can therefore vary in effect depending on the amount of endorphin present in the central nervous system. Descending fibers from the brainstem, limic system, thalamus, hypothalamus, etc. stimulate the production of endorphin in laminas I and V of the dorsal horn. Endorphin produced in the central nervous system through peripheral electrical stimulation is distributed on a segmental basis and later consumed at the area of production.

People with insufficient levels of endorphin tend to suffer more easily from pain ; higher than average amounts of this substance are generally found in the blood of patients with chronic algetic diseases. Endorphin insufficiencies in the limbic system appear to induce depression, while large amounts seem to bring on euphoric states.

3) The suppression of substance P. Substance P is a tachykinin of eleven amino acids found in minute quantities in the brain and intestines ; it produces pain and acts as a potent vasodilator. It is believed that endorphins inhibit the discharge of this substance.

4) The psychological suppression of pain. The psychological factor in the consciousness of pain is quite large, making it quite susceptible to the influence of race, culture, religion, habit, etc. Chronic pain can lead to depressive states, causing changes in personality and behavior. Generally speaking, women and the elderly tend to have a lower threshold and tolerance for pain.

h. Pain therapy

A number of approaches are possible in the treatment of pain : removal of the cause, blockage of the transmission pathway, psychotherapy, etc. The aim of these methods is to increase the pain threshold and/or suppress the pain reaction.

In surgery, it is necessary to limit the extent of damage as much as possible in all sections of the operative fibeld, taking particular care in the matters of soft tissue heat preservation and preventive measures to reduce postoperative scarring and contracture.

The generally employed methods of pain therapy are as follows.

1) Heat therapy. Heat a) has a localized analgesic effect ; b) serves to improve circulation and to aid the body's removal of metabolites and pain-producing substances (histamines, serotonin, etc.); c) increases the blood flow by lowering muscle tone and reduces pain by easing spasticity and contracture ; d) causes a pain-reducing autonomic reflex by acting upon the skin to either stimulate or suppress the sympathetic nervous system (hot baths of 42°C and above stimulate the sympathetic nervous system, while warm baths of 36° to 39° C stimulate the parasympathetic nervous system. Generally speaking, heat therapy gives the

vascular system a thermolytic function, and helps prevent tissue damage through the process of overheating.

2) Cold therapy (crynotherapy). Cold stimuli a) raise the threshold of the pain transmission system by i) dulling the activity of the naked nerve endings and reducing their discharges, ii) suppressing gate control, and iii) increasing the production of endorphin in the brain and spinal cord ; b) reduce pain through the production of reactive hyperemia and the increased removal of pain-causing substances ; c) lower the temperature of the muscle spindles, reducing their afferent discharges and thereby easing muscle spasticity for an analgesic effect (the lessening of muscle tension improves blood circulation and eases pain. Chilling acts in much the same way upon the muscle spasms and pain caused by disorders of the joint system and irritation of the nerve roots. Generally, when the spasticity of a painful muscle is suppressed, the activity of the antagonistic muscles is increased. When the antagonistic muscles are strengthened, recriprocal action leads to a suppression of spasticity); d) suppress the activity of destructive enzymes in the joints. Chilling reduces bursitis inflammation and the edema caused by vascular constriction, relieving nervous irritation and hence lessening pain.

3) Electrotherapy. The action of this type of therapy is generally explained on the basis of the gate control theory and/or the endogenous pain control mechanism.

4) Touch and pressure therapy. This type of therapy attempts to restore homeostasis to the autonomic nervous system and rectify muscle tone through tactile and pressure stimulation of the peripheral areas. The effect can be either to tonify, through quiet, gentle, and rythmical techniques, or to stimulate, through quick, vigorous techniques of varying strength ; it must thus be kept in mind that opposing reuslts can be obtained depending on the methods used. Tonification is generally sought for analgesic purposes.

This type of therapy is suited to the treatment of pain caused by a) increased muscle tension, b) nervous strain in the sympathetic system, c) nervous strain in the parasympathetic system. The techniques appropriate for these conditions include a) continuous palm pressure, b) gentle tapping, c) rolling and rocking methods in massage and shiatsu.

5) Therapeutic exercise. Therapeutic exercise aids in the improvement of circulation and the alleviation of spasticity, muscle tension, neurothlipsis, and the trigger point syndrome*. Among the various methods used are stretch exercises, isometric exercises, spasticity-inhibiting exercises, relaxation exercises, rheumatism therapeutic exercises, and Williams, Bohler, and Codman's therapeutic exercises.

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* Myofascial trigger point syndrome. The word "trigger point" indrcates the condition in which disorders in a particular nerve leave tender points and referred pain, accompanied at times by the presence of tubercles. This syndrome results in weakened muscles and functional disorders in the joints, developing at times into organic disorders. Synovial swelling, hyperemia, and effusion are also believed to be influenced by this condition. Treatment includes:

1) Local anesthesia.

2) Physical therapy: i) cold packs ii) acupuncture, iii) electrotherapy, iv) vasocoolant spray, v) stretching, vi) deep massage, vii) resistive exercise. Such treatments suppress the activity of the trigger points, raise poin thresholds, help clear metabolites, and, through somato-sensory stimulation, help activate autonomic reflex functions, endorphin production, and the gate control mechanism.

2. Occurrence Rates of Phantom Limbs, Phantom-limb Pain, and Stump Pain

A survey of 408 amputees using Kouseinenkin-type prostheses revealed that phantom limbs had been experienced by 67.4% of the 181 upper extremity amputees, 52.7% of the 205 lower extremity amputees, and 59.1% of the 22 multiple extremity amputees. Phantom-limb pain was reported by 76% of the 122 upper extremity amputees who had experienced phantom limbs and 78% of the 108 lower limb amputees in the same category. The fiqures for stump pain were 49% of the original 181 upper extremity amputees (57% of the 122 phantom limb cases) and 39% of the 205 lower extremity amputees (53% of the 108 phantom limb cases). Phantom-limb pain in coexistence with stump pain was felt by 47% of the upper limb amputees and 46% of the lower limb amputees. Little stump pain was reported by pediatric amputees.

A study of 168 certified handicapped persons in Shimane Prefecture with amputations and disarticulations proximal to the wrist or ankle revealed that phantom limbs were experienced by 75% of the 71 upper extremity amputees and 55% of the 93 lower extremity amputees. Phantom-limb pain was reported by 43% of the 53 upper extremity amputees and 41% of the 51 lower extremity amputees who had experienced phantom limbs. Those reporting stump pain were 30% of the original 71 upper extremity amputees (36% of the phantom limb patients) and 27% of the 93 lower extremity amputees (41% of the phantom limb patients). The coexistence of both phantom-limb and stump pain was reported by 23% of the upper extremity amputees and 22% of the lower extremity amputees.

3. Analysis of the Types of Pain Found in Phantom-limb Pain and Stump Pain.

Phantom-limb and stump pain are described by most patients in much the same way. Generally used are such adjectives as "electric," "burning," "dull," "cutting," "spasmodic," "numbing," "gripping," ect. Such pain is said to be associated with the central nervous system, similar to the sensory disturbances occurring in conjunction with thalamic disorders.

Generally speaking, though, expressions of pain tend to be milder in cases of phantom -limb pain than in cases of stump pain, and in lower limb amputations than in upper limb amputations. In addition, phantom-limb pain appears to have more of a central pain character than stump pain : patients complaining only of the former condition tend to use sharp words like "burning'" "cutting," and "crushing" to describe their pain, whereas patients complaining only of the latter condition tend to describe it with imprecise words like "dull" and "numb."

Phantom-limb pain tends to override the sensation of stump pain. In general, phantom -limb pain and stump pain are sensed as independent entities only when the former is significantly separated from the site of amputation ; as the two move closer together it becomes increasigly difficult to differentiate the two forms of pain.

4. Psychosomatic Elements of Phantom -limb and Stump Pain

Phantom-limb and stump pain tend to increase in noticeability and intensity at times of stress, fatigue, and higher than usual heat and humidity. These are much the same factors that influence pain in diseases like Rheumatoid Arthritis that have a strong psychosomatic

element. Psychosomatic factors thus appear to play a part in the expression of phantom-limb and stump pain. It seems logical that stump pain would bear a close connection with the physical condition of the amputation site, particularly with regard to scarring and adhesions, but observation does not always bear this out : many cases exist where no stump pain is felt in spite of various physical complications at the stump.

5. Treatment of Phantom-limb and Stump Pain

Approximately half of all cases of phantom-limb and stump pain require some form of therapy. Cases in which the two forms of pain coexist tend to necessitate treatment more often than cases where they are separate.

Pain found in type I and II phantom limbs is generally treated with massage and heat therapy, while that found in type III phantom limbs usually requires the use of medication and electrotherapy. The latter type pain is thus of a more serious nature. Types I and II phantom limbs are useful as feedback mechanisms when unaccompanied by pain ; when pain exists, it is felt to indicate the patient's unresolved desire for his lost limb.

6. Right and Left Side Differences in Phantom-limb Pain

A state of laterality is said to exist in the cerebrum, with the left hemisphere controlling such functions as speech, logic, and analysis, and the right hemisphere controlling the more creative functions of perception, intuition, and visual interpretation. Thalamic pain is often associated with right thalamic damage. Central pain is also found with right thalamic and right superior thalamic damage ; left thalamic damage can appear in the form of aphasia (Kameyama).

The occurrence of lower extremity phantom limbs is greater on the left side than the right, and the left side as a whole presents more difficulties with regard to phantom-limb pain and type III phantom limbs. Similar problems are found in the left side concerning the treatment of stump pain with central pain characteristics.

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